Research on the Design of Product Service Systems Based on Different Geographical Areas

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Abstract: Currently, the research field of industrial product service system design is immature and design models need to be improved. A territorialised design approach can effectively address these issues [1]. Geographical design refers to the use of design in system design to support the sustainable design of the system. While a new, more sustainable business model for production and consumption systems has begun to emerge internationally, this global generalisation does not necessarily lead to improvements in product service design. The construction of the ontology is based on the position and role in the design of industrial product service systems. The article suggests that advances in geo-based information technology have made this situation more complex. Therefore, shifting the level of design from the global level to the regional or local level allows for a clearer, timely and pragmatic interpretation of sustainability. The article explores territorialisation as a new design approach to support the design of service systems for industrial products. In order to meet this need, designers need access to geographical information that enables them to be incorporated in an appropriate way into the design specifications for territorial product services. In this context, ontologies can play an important role in the analysis and discovery of GIS within the product lifecycle and associated service networks. Sustainability enhancements may be the result of this integration. The article focuses on the environmental pillar.

Keywords: Product Service Design, Regional Geographic Systems, Life Cycle Impact Assessment, Product Development

1. Introduction

The implementation of information retrieval processes is a fundamental function of the IPS2 (Industrial Product Service System) component. It complements the existing knowledge of manufacturers and is the basis for the continuous improvement of products and services and the corresponding processes and resources [1]. Although information plays a key role, none of the information dimensions of IPS2 are relevant for GIS [2]. The design parameters of the product lifecycle phase can vary considerably, as the likelihood of using a particular product varies depending on the industry sector [3]. The industry already has a very similar understanding of this terminology, but without the support of GIS in its decision making. In practice, therefore, GIS is no longer a key

technology and it is unlikely to be used by all users. This poses new academic challenges that must be addressed.

How will geographic information territorialise the design of IPS2 and what will be the implications of this new design approach for sustainability? As this research is still in its infancy, the development of an ontology model visualised in a unified modelling language will help us to answer these queries. The main aim of the ontology development is to help clarify the top-level concepts of IPS2 and GIS integration, which will facilitate better communication of these concepts between researchers and practitioners [4]. This work included gathering concepts for public sector design guidelines and GIS, defining each concept, grouping the concepts and delineating the hierarchy, and identifying the relationships between these concepts. The "Abstract" provides the background to the article. The second chapter, "Literature Review", presents the history and current status of ontology research and introduces the main elements of the article. This is followed by a section on industrial product service systems, which introduces the concepts in the literature, and a section on 'Geographical sustainability', which explores opportunities for environmental sustainability through the use of geographical and environmental information. The article presents a model that builds on the concept of regional GIS and proposes a 'proposed model' to explain the relationship between these concepts. This' proposed model 'section describes the model in detail and concludes with a' conclusion '.

2. Literature Review and Methodology

As this research is still in its infancy, a review of the literature shows that the terminology used to describe IPS2 varies considerably. Therefore, ontology development is used as a method in starting and defining the ideas presented, which are defined as explicit formal normative terms and their interrelationships in the field [5]. An ontology can take many forms, but it must include a glossary of terms and some explanation of their meaning. This includes indications of how the defining concepts interrelate, which together specify the structure of the domain and limit the possible interpretations of the terms. The challenge is not to create a completely different IT structure, but to develop a common representation of IPS2 in the community. The aim of developing a standardised ontology is to encourage the conceptualisation and implementation of useful methods and tools by helping researchers and practitioners to communicate and share their views with each other. The article presents the initial structure of the IPS2 ontology from a design perspective.

3. Industrial Product Service System (IPS2) study

Business-to-business markets and business-to-customer markets tend to offer integrated and mutually defined planning, development, supply and use of products and services that are sold as a package to meet customer needs. In industrial applications, these combinations of products and services are called product service systems or industrial product service systems [6]. Foreign designers define IPS2 as a combination of tangible products and intangible services that provide value to the customer throughout the product's life cycle [7]. From the perspective of the IPS2

manufacturer, the product life cycle begins with the design of the industrial product, followed by its manufacture, maintenance and remanufacture; from the customer's perspective, it includes the purchase, use and disposal of the product. With these considerations in mind, designers must consider the manufacturability, maintenance and remanufacture of the product, and subsequent optimisation. IPS2 is a service-oriented architecture design philosophy that emphasises the relationship between the product and the customer and how the product adds value to the customer at all stages of the process, from manufacture to consumption; with a focus on the user experience. Non-physical services that support the customer are considered during the purchase, use and disposal of the product.

3.1 Product model concept study

The global market's demand for high-quality, low-cost products with shorter development cycles has led the industry to focus more on the development of new product design strategies. While each product design strategy has a different focus and approach, they all share a basic requirement: the need for advanced information technologies to integrate and coordinate product design activities [8]. The core issue of these information technologies is product modelling, i.e. the generation of an information base of product data to support the different phases of product design activities. However, current product models have a number of shortcomings, such as a lack of scalability, difficulty in adapting to changes and an inability to exchange data effectively with other tools. Therefore, it is imperative to create a product model that is suitable for the company's own characteristics. In order to introduce the idea of product modelling into industrial design applications, a practical approach is needed to gradually realise the benefits of the application.

Different modelling languages are used to represent different product information, e.g. the geometry seen in STEP is represented in PROE and the geometric patterns defined in the Core Product Model (CPM) are represented in UML (a modelling language that refers to the use of model elements to form a model of the whole system) [9]. Both approaches are built on object-oriented techniques. With these modelling approaches, users can more easily understand and control new product processes. This design thinking has been applied by many companies. The main motivation for this STEP is to achieve interoperability and to enable the exchange of product data between different computer systems and environments related to the entire product life cycle. The CPM model provides the core technology for product development information and can form the basis for future systems [10].

3.2 Product service model concept study

Service development method statements can borrow elements from product development requirements. However, when attempting to apply these requirements to service development, a fundamental definition problem is soon encountered within the service sector. Although different classification schemes have been proposed, none of the approaches are very generic. In the field of service systems, the most common way of classifying services is to divide them into three categories based on the user requirements for service quality: satisfiability (availability), reliability, and

responsiveness [11]. For each category of services, they have their own specific characteristics. A typical service can be divided into three different dimensions: the structural dimension (the ability and willingness of the structure to provide the service under discussion), the process (the service is provided according to or using external factors of the integration process) and the outcome (the outcome of the service has certain tangible and immaterial consequences on external factors). These three aspects must be taken into account when developing services. Logically, appropriate models and concepts should be provided for each of these dimensions in the development process. The outcome dimension can be represented by a product model, which usually includes the definition of the service content and the planning of the service product structure. The product model can reflect the functionality of the service, while the process dimension can describe how the service is implemented.

4. Regional and Sustainable Development Studies

Sustainable development is an important global issue that seeks to address the problems in any resource - use activity. In many areas, "sustainability" has become a universally accepted concept and is widely followed and applied [12]. This is no exception in the field of industrial products. In many cases, designers emphasise sustainability. Unfortunately, sustainability has so far played a minor role in design education and design practice. Design has not been considered a relevant element in the sustainability discussion. Therefore, product development and redesign based on the concept of sustainability may be the solution to changing consumption and production patterns in the future. The three pillars of sustainability necessarily interact geographically, with regional structures forming a complex and diverse system that defines and manages sustainability. In turn, these three pillars will affect the whole region. The article proposes a new approach to territorial analysis, which takes a 'regional' approach to how products meet the needs generated by local communities. This relates to the sustainability of the territorial system in terms of the environmental, social and economic structure of a given location. The use of this territorial approach adds value to the assessment of all products, but it is particularly important to have adequate territorial and environmental information [13].

4.1 Study of regional geographical factors

A GIS is a special case of an information system that combines spatial data and descriptive data. Spatial data usually consists of geographic entities, while geographic information is expressed in the form of maps; therefore, GIS has powerful data processing and mapping capabilities. The article discusses the benefits of GIS applications in product design. His functions include spatial visualisation, database management, decision modelling and design and planning. Spatial imaging refers to the basic ability of GIS to display data and information in a spatially determined coordinate system. Database management functions are the ability of a GIS to store, operate and provide access to data. Decision modelling functions are the ability of GIS to support analysis and decision making. The design and planning function represents the ability to organise and describe spatial concepts. The article describes these main application modules and the basic functions they each have. It then discusses how they relate to each other and how they are used. Finally, the design and planning

function represents the ability to create, design and plan a GIS [14]. Although environmental, social and geographical characteristics and regulations vary from region to region, product designers need to take these differences into account in order to be able to manage the environmental, economic and social aspects of their products and services. One of the most effective ways of linking product design to sustainability issues is therefore based on the geographic location or space of a geographical location. In achieving this, GIS can play a variety of roles: as a data source for model input, a way to display and query model output, or as a more integrated mechanism.

4.2 Study of the impact of regional environmental factors

Today's business is a highly complex system of multiple, geographically distributed business and process units working together. This makes it more difficult for businesses to deal with sustainability issues in line with customer and regulatory requirements. In the field of sustainability, Life Cycle Assessment (LCA) is an important tool that helps to ensure appropriate sustainability by assessing the environmental impact of product design. It includes: product life cycle management (LCA), environmental impact assessment (SEA) during the design/development phase and environmental impact assessment during the whole product life cycle (PLM) [15][16]. KL life cycle assessment has become a necessary step for companies to achieve their strategic goals. In a life cycle assessment, the whole process or product is analysed, taking into account both upstream and downstream processes from start to finish. In addition, the nature of each geographical aspect can be expressed in the structure of the LCA as three branches of the technical, environmental and social system, where the link between 'production' and 'process' is in some way proportional to the 'territory'.

5. Modelling of the programme

Engineering designer personnel, service personnel and marketing personnel design product and service designs respectively. It is argued that services can have a significant impact on product design. The article first describes a product design approach based on the theory of IDEF0 (a tool for systematic menu representation developed on the basis of structured analysis and design techniques) and a service design approach based on IPS1 [17]. A new service-oriented design system, IPS2, is then presented. Due to the characteristics of IPS2 described above, it is structured as a combination of product and process throughout its lifecycle. The proposed model is therefore a synthesis from existing product and process models that already interact with GIS. Based on the feedback and comments received, the model has been revised and amended and the details of these are outlined in the following.

As a selected model of a product, the CPM is strongly influenced by the entity-relational data model and consists of two classes, object and relationship, which are equivalent to UML classes and association classes respectively. After analysing the characteristics of both types of relational data models, a new integrated framework for manufacturing system-oriented product design based on an object-oriented approach - CAPM-FDM - is proposed and applied to practical product development. The framework can be divided into three phases. Mainly as shown in the proposed model notation

(UML) in Figure 1 Unified Modelling Language, the types of models include: artefacts representing any physical entity in the product; machining equipment: the assembled or assembled artefacts being manufactured; production systems: all machining data received from the factory is organised and stored in a database; client/server: the user accesses the services provided by the factory and related information. Features: form of the workpiece; form: geometry and material; function: expected behaviour; behaviour: how the form functions. Oam feature (operations maintenance management feature) is a special feature in the open assembly model extension that supports product structure, assembly and relationships between components etc [10]. Environmental issues include three aspects: firstly, hazards to the product itself; secondly, damage to the environment; and thirdly, threats to human health. The harm to the product itself consists of two components: environmental pollution and ecological damage. The environmental impact is determined by the flow, so the effect of the process is the sum of the impact of the flow. In the flow category according to resources: physical goods material goods components and consumable tools; non-material goods such as energy or even substances [18]. Eol (end of life) includes reuse and waste: recycling (waste reprocessed into products), energy recovery (waste recycled as combustion fuel or compost) and disposal (landfill or incineration plant). Finally, the use of categories is related to the consumption of products in their use phase and is also closely related to the type of service.

In the proposed model, the main purpose of the classes "Topic" and "GeoRegion" that make up any geographic application is to manage and manipulate the geodatabase of the specific regions that make up the geographic dataset. The Geographical Area class has an aggregated relationship with the Lifecycle List, which is a connector to the Affected Category class. The lifecycle list is a connector to the impact category class. By aggregating the class into a geodatabase to create a map system and providing a new visualisation tool to analyse this information, the user's ability to understand complex geographical phenomena and their processes is improved. The thematic courses introduce five geographical themes (places, locations, interaction of the human environment, sports and regions). The system allows for the selection of appropriate sub-themes based on user needs and the combination of these themes to produce the required thematic information. By using concept mapping-based technology, the system is able to provide rich and effective functionality. A collection of themes can be identified for each geographical area [19].

6. Case study of an electric kettle

The design approach is not imagined and requires us to adopt certain methods to evaluate it. We again regionalised the design of the electric kettle and developed a revised design to validate the effectiveness of the proposed design approach revision. Based on this, the paper further explores the relationship between user experience elements and design outcomes in product design, culminating in a case study to illustrate how user experience can be integrated into design. First, a product service model and a product lifecycle process model were developed based on the lifecycle and bill of materials of a current electric kettle Figure 1. Then, the Champagne Ardennes region in north-eastern France was selected and the kettle was redesigned to the specifications supported by the GIS.

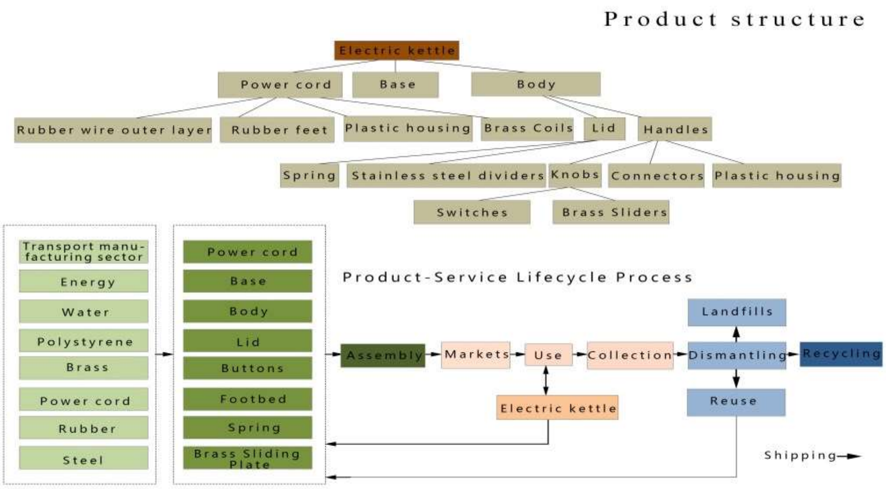

Figure 1 Life cycle and bill of materials of existing kettles

As shown in the geographical illustration of the life cycle steps of the existing electric kettle in Figure 2, the original product structure model is not applicable to the proposed model because some raw materials and components are imported from outside the defined area.

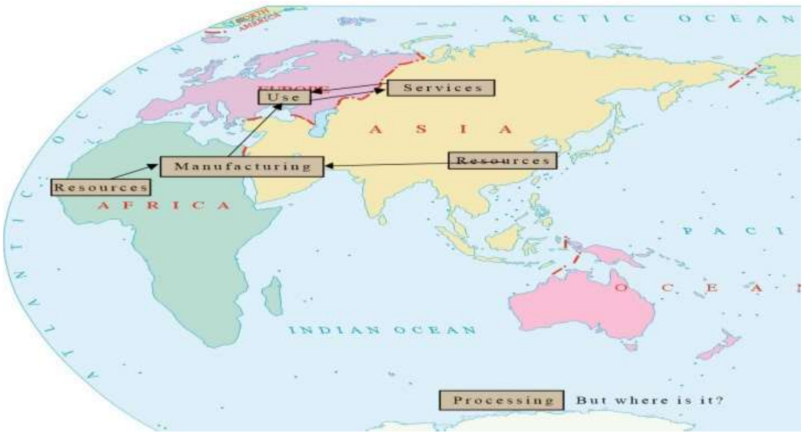

Figure 2 Geographical illustration of the life cycle steps of an existing electric kettle

In previous designs, the body and base of the kettle were made from polyethylene from China and shipped to other countries. This plastic is now used to make the housing and handle of the kettle. In the design, the designers used a variety of different methods to reduce costs and increase production efficiency. They have also used advanced technology to ensure the quality of the product. In the new design, polyethylene is an agricultural raw material from South East Asia, which is the largest potential source of material.

As a next step after assessing the function and performance of the new material, wood was chosen instead of polyethylene and the original electric kettle hierarchy, connectivity and layout (geometry) were modified in order to redesign Figure 3. In order to meet these requirements, the dimensional

and weight parameters were first determined. On this basis, the connections between the various parts were then decided and finally the parts were assembled. In other words, the body, the base and the power cable are three different parts that should be built as one integral part in order to have sufficient strength.

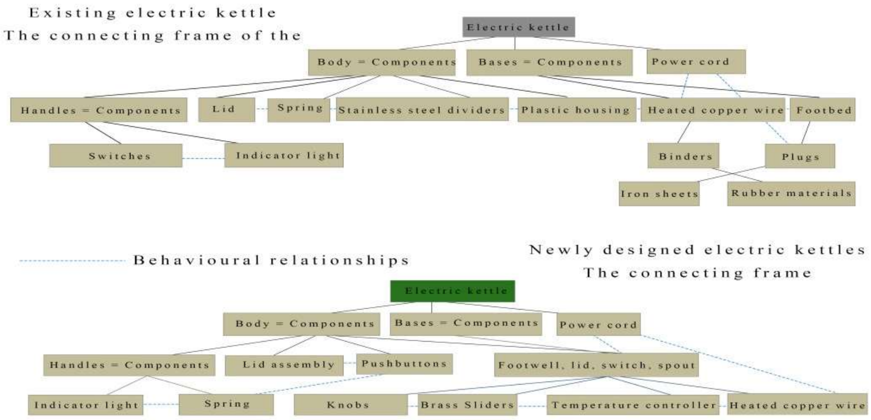

Figure 3 Relationship between the newly designed product and the existing product structure

To evaluate the environment of a newly designed product, choose a simplified LCA (product life cycle analysis) rather than a detailed LCA evaluation. Using SimaPro (an LCA life cycle assessment software, software that helps users to analyse product scenarios and helps them to make clear decisions in business) the software simplifies certain phases of the product and its life cycle to limit the data involved in the design process [20]. Q The life cycle phases include the selection of materials, and potential regional impact categories include acidification, eutrophication and climate change. These factors can be analysed by modelling the lighting system. The results are combined with practical applications and the interactions between different parameters are considered. The method can be used to determine whether one or more design options will meet the desired objectives. The aim of this simplified study is to verify the environmental benefits of using area light sources for the design of electric kettles.

The results of the new life cycle assessment show that the elimination of the choice of polyethylene material and long distance transport has resulted in a better design solution from an environmental impact point of view and meets all initial requirements as shown in Figure 4.

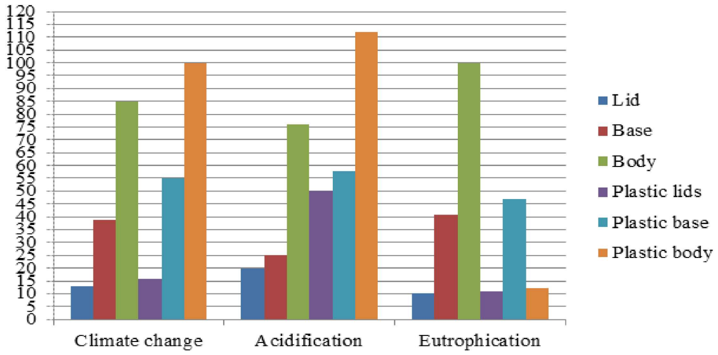

Figure 4 Product component life cycle assessment results

The solution is to use an electric kettle made of wood. It has excellent properties in terms of heat retention, environmental friendliness and reusability. Its construction includes components such as the housing, the base and the power supply. Pro/E software was used as an aid in the design process. The design was first defined. The product designer modelled the final product using Rhino software as shown in Figure 5.

Figure 5 New and existing designs

A thorough analysis of the above methods shows that the existing product in Figure 5 needs to be designed as an electric kettle with a wooden body. However, in the specific design, the designer must take into account aspects such as the structure and function of the product itself in order to make the design solution more reasonable and practical and thus meet the needs of people for lighting products. Therefore, the designer must start from many aspects. This is the next step in the design service, but of course, not the absolute right approach. Therefore, more design practice is needed to support this approach.

As the modelling of new products and related services requires structural changes, their feasibility needs to be further assessed. Factors such as reliability, manufacturability and marketability are taken into account, for example. In addition, accurate data relating to services, products and geographical locations should be added at a later stage of the life cycle design to allow for more accurate modelling. This new model will be used to effectively manage the consistency between the product model, the service model and its relationship to the specified region. However, social and economic consistency should be supported by the model. To address this issue, the article proposes an integration technique based on geospatial location. It can help managers to identify the key elements they are concerned about. The solution proposed in the article has been shown to work well in one instance, and developing such a management approach is one of our future goals.

7. Conclusion

This work is not in itself the development of a new model, but rather an attempt to demonstrate the important role of geographic information in the design of product services. It involves two main aspects: 1. The conversion of spatial data into graphics; and 2. The transformation of graphics into comprehensible symbols. The article discusses this process. It also concludes with a description of how GIS technology can be used for product service design. It is expected that the core model presented in this report, with appropriate empirically based modifications, could be used as a mechanism for information transfer for a new generation of product development tools, either in the basic form proposed in the article or as a basic formulation of a multi-level design information flow model.

In summary, the article shows that GIS can be incorporated into product service design models. Site-specific environmental, economic and social factors are identified in the design of sustainable products. This information is used to determine the best design solution and to assess the ability of the product to impact on human health and the environment. This technology can also help companies to make the transition from product to service. The systems described in the article have been used in real projects.

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